XLVIII.—*On Calcareous Hexactinellid Structure in the Devonian Limestone; large Fossil Hydrozoic Coralla from the Chalk; and further Observations on the Replacement of Silex by Calcite.* By H. J. Carter, F.R.S. &c.

On the shores of Teignmouth and Dawlish, in Devonshire, just after the New Red Sandstone touches the Devonian Limestone of Torbay, the former contains a number of fragments from the latter, which, as the Red-Sandstone cliff yields to the approach of the sea, fall down upon the beach, and, becoming rounded by the action of the waves and sand, are at length picked up by the lapidaries, who, selecting those which present the prettiest structure, cut and polish them for sale.

It was one of these which Mr. Sollas obtained at Dawlish, that he presented to me, I think, in the summer of 1875, and to which I have alluded as presenting a structure which, "*like* all the rest of the *Stromatoporæ*, requires to be studied in all its bearings before a correct opinion can be obtained of its original nature" ('Annals,' 1877, vol. xix. pp. 72, 73); but since the possibility of silex being replaced by calcite during fossilization has been established, and I have, through the great kindness of Prof. Zittel, received many specimens of several fossil Hexactinellid sponges, and have become better acquainted with the structure of *Stromatopora*, I have come to the conclusion that the polished pebble presents a hexactinellid structure, which, if not a sponge, was still not a *Stromatopora*.

Mr. Sollas kindly gave me polished horizontal as well as vertical sections of the structure; and on looking out among Prof. Zittel's specimens for that which is most like it, I find that, to all appearance, it is identical with *Verrucocœlia gregaria* (Quenst. et Zittel; *Verrucocœlia*, Etallon) ('Annals,' 1877, vol. xx. p. 503). The specimen is two inches in diameter, and appears to have been cut from a circular pebble about an inch in thickness.

Having, however, lately visited my friend Mr. Vicary at Exeter, whose collection of sections of *Stromatopora* (which were obtained by a gentleman from the locality mentioned, during a residence of twenty-five years in the neighbourhood of Teignmouth) consists of between three and four hundred specimens, I found two among them possessing this hexactinellid structure, but slightly modified; that is, the vertical lines in the vertical section are larger and more evidently hollow, but with no *tabulæ* or transverse septa, while here and there, on the horizontal section, are intervals tending to a stellate arrangement resembling the like in *Stromatopora*.

Still here the resemblance ends; for the cœnosarcal skeleton

is hexactinellid, not formed of a convoluted fibre like that of *Stromatopora*, and there is but one kind of pore on the surface, viz. that of the vertical lines, not two sizes as in *Stromatopora*, while the tubular lines are without *tabulæ* as just noticed; at least this is the type to which I allude.

Here it might be mentioned that there are two distinct features in *Stromatopora* which distinguish it from sponges: viz., 1st, the vertical tubes in *Stromatopora*, being for the full-grown polyps, are of the same size throughout, while all the tubes of a sponge, being parts of the excretory canal system, continue increasing in size from a mere point to their termination in the oscule or vent; and, 2nd, the vertical tubes in *Stromatopora* are interrupted by *tabulæ* or transverse septa, which do not exist in the excretory canals of the sponge. Thus, as I have before stated, *Stromatopora* more nearly resembles *Tubipora musica*, but most of all *Millepora alcicornis*; while the hexactinellid structure to which I have above alluded is more like that of the fossil hexactinellid sponges—to wit, *Verrucocœlia gregaria*, Zitt.

Doubtless in the Devonian Limestone (which may be said to be one mass of corals, of course including the *Stromatoporæ*, particularly near Newton-Abbot, where Mr. Vicary tells me there is a quarry in which not a fragment as large as a man's fist can be found without containing one or more species distinctly and beautifully differentiated, and therefore originally was probably a coral reef) there were also sponges possessing the hexactinellid structure above mentioned, unless the latter belonged to something else; but, be this as it may, thin slices alone will not decide the question, which can only be determined by the possession of a whole form for dissection. Doubtless, too, there are gradationary forms which link the Actinozoa to the Hydrozoa; and these may be accompanied by their respective coralla; so that it must not always be laid down that because the corallum is like that of an Actinozoon it must necessarily have been one, or *vice versâ*. To prove that this hexactinellid structure was a sponge it would be necessary to show that it possessed spicules, or at least an excretory canal-system like that of sponges, which can only be done by sectioning an entire specimen, such as Mr. Vicary kindly gave me of *Stromatopora* for comparison with *Millepora alcicornis*.

Pursuing the subject of extinct Hydrozoa still further, I find among Dr. Bowerbank's collections several kinds of fossils labelled "Flamborough-Chalk Sponges," chiefly composed of chalcedony with a little chalk here and there, viz.:—No. 1. Subglobular, about the size and shape of a walnut, 1 inch in

diameter. No. 2. Pyriform, stipitate, smooth, with circular concentric lines of growth, slightly compressed, 3 inches long; free or large end convex, 3 × 2 inches in diameter, with a funnel-shaped excavation in the centre ½ inch wide; the stem broken off 3 inches from the summit, and 7-8ths × 6-8ths of an inch in its diameters at the fracture. No. 3. Much the same, but extended into a cylindrical form 1 foot long, and the stem broken off as in no. 2. No. 4. Much the same, but the cylindrical portion deeply and irregularly constricted at varying intervals, so as to present a dozen segments; ending above in being divided into a few thick conical processes, but too imperfect to state how many, or whether there was any excavation in the centre as in nos. 2 and 3; covered throughout with cup-like raised cells 1-24th inch in diameter, and about 1-8th inch apart, more or less; uppermost segment 4 × 2 inches; deepest constriction, which is just where the pyriform passes into the segmented cylindrical one, 2½ inches in diameter; total length to the end of the stem, which is broken off, 15 inches, diameter of fractured end of stem 1 inch. No. 5. Agaricoid or tabular; head or tabular part presenting concentric lines of growth on both sides, with holes 1-24th inch in diameter, in juxtaposition on the upper surface, like *Favosites*; below, crooked lines of elongated cells radiating from the stem to the circumference, where they become more or less vertical to form the margin of the head; tabular portion 4½ inches in horizontal and 4-8ths inch in vertical diameter; stem round, expanding into the head, ½ inch in diameter at the fracture. No. 6. Vasiform complete or incomplete, 4 inches across the brim; wall ½ inch thick; prolonged conical apertures 1-8th inch in diameter at the base, and 1-24th inch at the aperture, sparsely scattered over the inner surface, about ¼ inch apart, more or less, the same on the outer side, but smaller in every way and more closely approximated than those on the upper surface; margin round and without cells; stem broken off, about ¼ inch in diameter at the fracture. There are several specimens of nos. 5 and 6, all of which differ considerably in their general measurements; that is, some are much larger than others.

Now I am not going into the description of these fossils further than I have done, as this would entail more time than I can afford to spare from the study of the Spongida; but I cannot help thus briefly noticing their characters respectively, in order to introduce their nature under a more interesting and satisfactory form, I think, than appears to me to have yet been accorded to them.

Of their belonging to the genus *Scyphia*, Schweigger, = *Spongites*, Goldfuss, I think there can be no doubt; and I have at least identified no. 3 with fig. 12, *a*, *b*, tab. iii. in

Goldfuss's 'Petrefacta.' De Blainville rightly describes their structure as being composed of "un tissu entièrement réticulé" (Man. d'Actinol. 1834, p. 537); and D'Orbigny, "que leur tissu a toujours été calcaire et pierreux" (Cours de Géol. 1849, vol. i. p. 208): two higher authorities it would be difficult to find.

In both these characters I agree; but we must go a little further and endeavour to find out what the nature of the *organism* was that really built them.

We may notice, then, that in all the structure is laminar, and the base a convoluted fibre like that of *Parkeria*, which, when magnified, would, on the unbroken surface, represent the convolutions of a brain. This was the cœnenchymal skeleton, while in the midst of its labyrinthic structure was an equally tortuous canal-work which held the cœnenchyma itself, and which, again, communicated with the exterior through the sulcate lines between the convolutions. Thus the sulcate lines in their turn became part of the labyrinthic tubulation as the organism added layers to the surface of its corallum, just as in *Millepora alcicornis*. Mr. Chas. Moore's specimen, to which I have alluded ('Annals,' 1878, vol. i. p. 310), shows this most satisfactorily; for, like an uninfiltrated *Parkeria*, the tubulation is all *empty*.

So far nos. 1–3 inclusive resembled *Parkeria*. But this structure in no. 4 was accompanied by straight tubes radiating from the centre at the commencement, increased in number with the increasing growth and extended circumference of the cylindrical corallum, terminating on the surface in the little holes or calicles above mentioned, among which the shallowest, of course, belong to the last layer, while the deepest belong to the first; these tubes are about 1-48th of an inch in diameter, and do not appear to have had any *tabulæ*. Much the same structure appears to have existed with the calicles in the agaricoid and vasiform varieties; only, of course, the distance from the surface to the centre in the latter is far less than that of the cylindrical form last mentioned.

Further, we observe that the cœnenchymal skeleton presents a layer of finer structure of the same kind on the surface, similar to that of *Millepora alcicornis* (just as the circumference of a tree &c. presents a finer structure on the growing surface than further in towards the stock); while just below this runs the "deep horizontal canal-system" of Moseley, to which I have alluded ('Annals,' 1878, vol. i. p. 305), which in some specimens of nos. 2 and 3, where it has been half rubbed off, shows the walls of the canal and its interior, now chalcedonized, as I have described it on the surface of *Millepora Woodwardii* ('Annals,' 1877, vol. xix. p. 65), while here

and there, passing obliquely through this fine layer, may be seen Moseley's *superficial* branches of this system.

I omitted to state in my last paper that although this system is only seen here and there on the surface of *Millepora alcicornis*, it comes into view directly the surface is slightly taken off with a very sharp knife; but it should be remembered that it is so thin that, as in *Stromatopora*, the least abstraction of the surface may bring it into view or remove it altogether, as the case may be.

Returning to the *surface* of these fossils, we find no. 1 possessing a hole laterally about 1-8th of an inch in diameter, narrowing inwards to near the centre, and issuing from it a number of grooves which spread over half the surface in a branched venation; while the other part, which is more or less dimpled like *Parkeria*, presents, every here and there, a stellate arrangement of such grooves issuing from the dimple.

Following this up we seem to find its homologue in the excavation at the ends of nos. 2 and 3, from which also proceeds the same kind of branched sinuous venation. Of the nature and function of the soft parts which occupied the hole and its grooved venation I cannot offer an opinion, further than that it might have been of the same nature and for the same purpose as that of the "horizontal canal-system," viz. for the formation of additional layers upon the test or corallum. The question may also be suggested here, whether the hole seen in many, perhaps most, specimens of *Millepora globularis* is not of the same kind ('Annals,' 1878, vol. i. p. 307).

Lastly, I must state here again that, as there are so many forms of the fossils figured by Goldfuss &c. under one head that belong to totally different organisms, many, indeed, to real sponges, as shown by Prof. Zittel ('Annals,' *l. c.*), it is very desirable, as I have before stated, that they should be all "relegated to their proper position in the animal kingdom" by the palæontologist. All I can do is to point out, as Prof. Zittel has done for sponges, the structure of those which have accidentally come before me that may be termed Hydractinian or Hydrozoic.

One cannot help seeing here, too, that while the Hydrozoa (as *Stromatopora*) played such a great part in the formation of the Devonian-Limestone reef, they were also very plentiful under other forms during the Cretaceous period, and that (in *Millepora alcicornis* &c) they are doing the same kind of work in the formation of coral reefs at the present day.

With reference to the replacement of silex by calcite I have just been examining a large fossil sponge from the Chalk more or less chalcedonized (in size $7 \times 5 \times 2\frac{1}{2}$ inches, shaped like

the "cap of liberty," compressed, conical, a little bent upon itself and formerly hollow, as indicated by a round plug of chalk, 1½ inch in diameter, in the centre of the large or free end, the smaller one having been the point of attachment; surface regularly cancellated, with interstices 1-24th inch in diameter), and find that by subjecting a portion to the dissolving influence of dilute nitric acid, a lithistid structure is brought out, in which part is chalcedonic and part calcareous, the latter in many instances having disappeared, while the former as often remains as a fragment of the original trifid lithistid spicule—just as in Prof. Zittel's case ('Annals,' 1877, vol. xx. p. 264). Here, then, it is perfectly evident that the originally siliceous spicule of the lithistid has, to a certain extent, been replaced by calcareous material.

At the conclusion of my description of Mr. Thomson's fossil sponges from the Carboniferous Limestone of S.W. Scotland ('Annals,' 1878, vol. i. p. 141) it is stated that, not only the chalcedonized spicules of *Hyalonema Smithii* present rhombohedral excavations, but the casts of turreted shells which are composed of chalcedony present the same phenomenon; and it might be added that, on the fretted-out surface of a large block of *Stromatopora* from the Devonian Limestone, I have just found casts of turreted and bivalve shells composed of calcite, which also present this rhombohedral excavation.

Here, then, we have three states, viz.:—1, the original siliceous sponge-spicule chalcedonized; 2, the casts of shells in chalcedony; and 3, the casts of shells in calcite, all presenting the same kind of rhombohedral excavations; and striking as it appears that the chalcedony and the calcite should respectively present the same kind of rhombohedral excavation, we are impelled to the conclusion, on the one hand, that the chalcedony is encroached upon by the calcite; while, on the other hand, the calcite, as a matter of course, weathers out in the form of its natural crystallization. I omitted to mention, in connexion with the former, that the fossilized spicules of *Hyalonema Smithii* do not present any of this double composition in the undecomposed Carboniferous Limestone, where they are quite smooth until subjected to the dissolving influence of an acid, when they acquire the same kind of rhombohedral excavation on the surface that is seen in the spicules of *Hyalonema Smithii* &c. when found loose in the "rotten" or disintegrated rock.

Lately Mr. Charles Moore, F.G.S., sent me some specimens of fossil sponge-spicules from the Liassic rocks of Brocastle, found also abundantly on the weathered surfaces of the Liassic rocks on both sides of the Bristol Channel, as a sample of

what have been supposed to be the remains of Calcispongiæ, from their triradiate appearance and calcareous composition (*Grantia antiqua*, Moore, Quart. Journ. Geol. Soc., Dec. 1867, p. 538, pl. xvi. figs. 33, 34). They are white, and all fragments of quadriradiate forms—that is, spicules composed of a trifid head and shaft, to me very much like the quadriradiates of *Pachastrella abyssi*, Sdt.; but be this as it may, among them was a head and part of the shaft of a trifurcate spicule which must have belonged to a siliceous sponge (*Geodia* or *Stelletta*), in the same condition of fossilization as the rest—that is, calcareous. I took a fragment of one from the parent rock, and having placed it in a little dilute nitric acid, saw it effervesce, and at last break down into minute particles; while Mr. Moore informs me that he treated some with hydrochloric acid, and they all disappeared.

Now it is very natural that trifid forms of sponge-spicule should be taken for those belonging to the Calcispongiæ, especially if they are calcareous; but it should be remembered that while there are very few Calcispongiæ which possess triradiates or quadriradiates sufficiently large to pass through the ordeal of fossilization without disappearing altogether, there are many Pachastrellida which possess both forms much larger than the largest of any that are known to exist in the Calcispongiæ; while the possibility of the siliceous spicule becoming calcareous during fossilization has, as above stated, been established.

Thus we may find separate sponge-spicules of the siliceous sponges and whole siliceous sponges themselves calcified; but it would not be right to call these "Calcispongiæ:" even "Calcificatæ" would be better than this.

With reference to the chalcedonized Pachastrellida and their spicules in the Chalk, I have now two beautiful specimens that appear to have been freed from the latter by an acid, each of which is from 3 to 4 inches in its longest diameter, one irregularly lobate, and the other vase-shaped, where the quadriradiate spicules, simple and trifid at the ends of their arms respectively, are identical with those of *Pachastrella abyssi*, Sdt., while they are so confusedly thrown together, and the mass thus rendered so characteristically asperous, that it is impossible to see in them any thing but a *Pachastrella*. Here too, in many parts, the trifid heads are alone visible, which might be easily taken for those of a Calcisponge—especially as *Pachastrella*, like the Calcisponge, being without that fibrous structure which entails regularity in the distribution of its spicules, appears to be entirely without arrangement of the latter; so that in this respect each looks like a bag of pins.

Thus we have undoubted evidence of the existence of *Pachastrella* in the Cretaceous period, but none such of a Calcisponge.

MISCELLANEOUS.

On the Young Stages of some Osseous Fishes: Development of the Tail. By Mr. Al. Agassiz.

In this valuable memoir the author refers to observations made in great detail principally upon *Pleuronectes*. The conclusions at which he arrives are of great interest in connexion with the succession of forms among fossil fishes.

The young *Pleuronectes*, on escaping from the egg, has the posterior extremity of its dorsal chord straight, and its caudal fin is rounded. Soon the extremity of the dorsal chord becomes greatly arched upwards, presenting a concavity towards the ventral surface; at this moment appears the first trace of separation between the embryonic caudal fin and the permanent caudal, as also the first indications of the principal and accessory rays of the tail. In the succeeding period the emargination which exists between the embryonic and the permanent caudal has become deeper and the chord is more arched, the rays are well marked, and the permanent caudal extends backward beyond the embryonic caudal.

In the further course of development the embryonic caudal acquires the form of a large independent lobe; the permanent fin extends entirely beneath it, and forms a distinct fin having the appearance of a second anal. On arriving at this point the caudal region of a young *Pleuronectes* presents a striking resemblance to that of the young *Lepidosteus* as described and figured by Wilder *.

The arch formed by the caudal extremity of the chord becomes still more strongly marked; and the permanent caudal extends at first as far as the embryonic caudal, and afterwards passes beyond it. The embryonic caudal is thrown more and more upwards; and the rays of the permanent caudal acquire a fan-like arrangement.

While these latter changes are taking place we observe a disappearance of the notochord, which precedes the formation of the urostyle. The embryonic caudal also disappears more and more, and finally only presents the form of a slight semitransparent thickening of the dorsal line. On the other hand, the permanent caudal increases continually; from being pointed it becomes rounded, and acquires the form seen in the adult. At the same time the ossification of the vertebræ takes place, the cartilages which support the rays appear, &c.

Mr. A. Agassiz has observed these same phases of development of the caudal fin in a great number of other genera of fishes belonging

* "Notes on the American Ganoids," Proc. Amer. Assoc. Adv. Sci. 1876 (Detroit Meeting).